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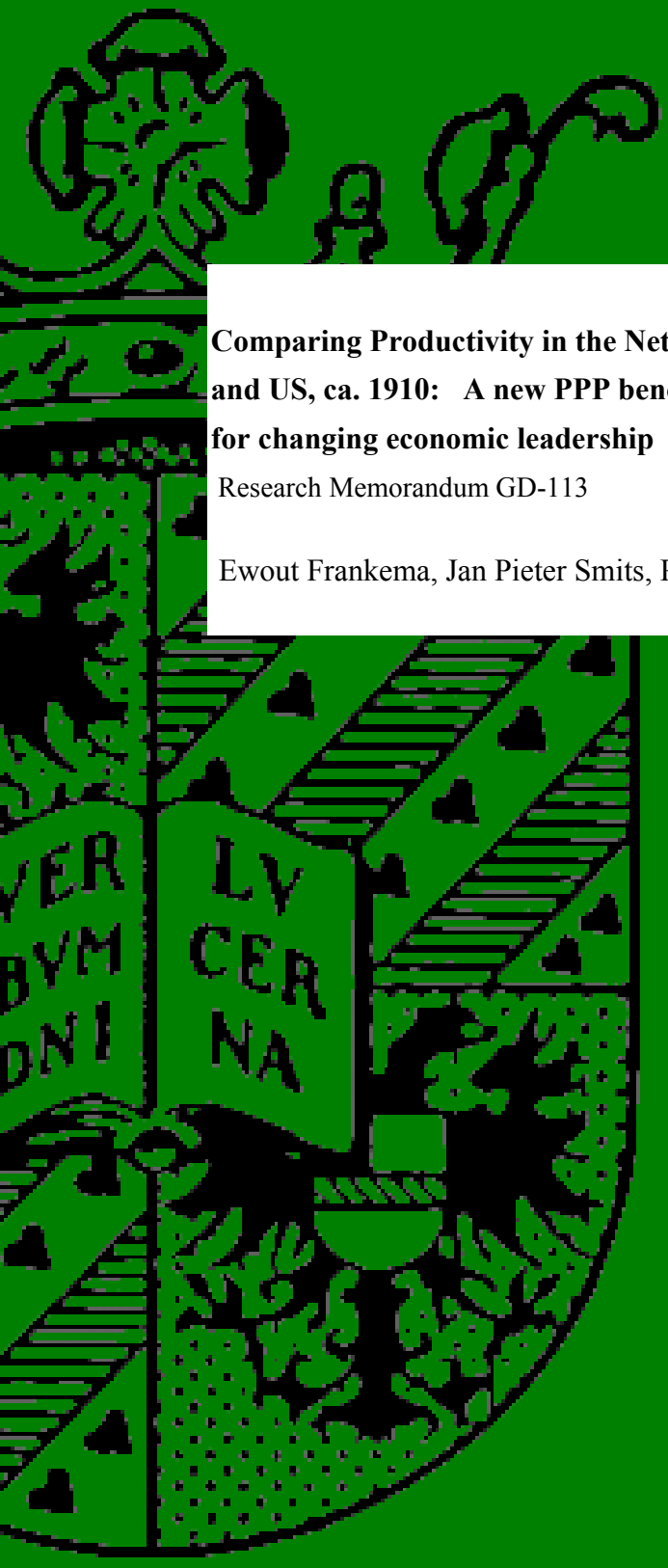

Comparing Productivity in the Netherlands, France, UK and US, ca. 1910: A new PPP benchmark and its implications for changing economic leadership

Research Memorandum GD-113

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RESEARCH MEMORANDUM

Comparing Productivity in the Netherlands, France, UK and US, ca. 1910:
A new PPP benchmark and its implications for changing economic leadership

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Abstract:
This paper presents a new benchmark of fisher weighted sector PPPs for agriculture, mining and five manufacturing branches in the US, UK, France and the Netherlands around 1910. The PPPs are constructed according to an industry-of-origin approach in order to assess comparative levels of labour productivity at a sector level. The estimates are subsequently used to build up a comparison of total labour productivity and GDP per capita. Our main findings are that the relative levels of labour productivity and per capita GDP in the Western European countries have been overestimated in the literature so far. A backward projection of our productivity estimates into the nineteenth century sheds new light on the timing of the take-over in productivity and income leadership between the Netherlands, UK and US. The US-UK take-over occurred between 1879 and 1899 in terms of GDP per capita, but we show that in terms of aggregate labour productivity the US was already world leader around 1850. The Dutch economy seems to have lost its economic leadership earlier than hitherto has been assumed.

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Acknowledgements: We are grateful to Herman de Jong, Jan Luiten van Zanden, Steve Broadberry, Knick Harley, Robert Allen and the participants of the session on Comparative Wages and Productivity at the Eighth Conference of the European Historical Economics Society (EHES), Geneva, September 4-5, 2009 and the Graduate Workshop in Economic and Social History of Oxford University, December 3, 2009 for their comments on previous drafts of this paper. We are also grateful to Marianne Ward and John Devereux for their permission to cite from unpublished work. The usual disclaimer applies.

1. Introduction

This paper offers a direct benchmark of fisher weighted industry-of-origin PPPs for the United States, the United Kingdom, France and the Netherlands around 1910. The industry-of-origin approach allows for a disaggregation of international productivity differentials at an industry level, which enhances a deeper understanding of the comparative economic performance of countries. The implications of our new PPP benchmark are investigated by focusing on two on-going debates in the historiography. First, we investigate what light our results shed on the Broadberry versus Ward and Devereux debate regarding the UK-US income and productivity differentials in the nineteenth century.[1] Second, we review the timing of the shift of economic leadership from the Dutch Republic/the Netherlands to the United Kingdom, which according to some occurred already in the eighteenth century, but according to the conventional estimates should be dated as late as 1850.[2]

Our new estimates of comparative labour productivity sheds new light on long-run changes in economic leadership as the Netherlands, the United Kingdom and the United States have been subsequent technological leaders from the seventeenth century until present.[3] In addition, France provides an interesting case, as it is one of the largest Western European economies, which followed a rather specific path of economic and industrial development.[4] It would have been preferable to also include Germany -a country which went through a dynamic phase of technological change and productivity growth from the late nineteenth century onwards- in this comparison. However, the required data for constructing industry-of-origin PPPs are that scarce that we decided to leave this important country out. We believe that charting Germany's productivity performance before World War I warrants a different research strategy.

Until now only a pre-World War I benchmark comparison existed for the United Kingdom and the United States.[5] We add new empirical evidence for France and the Netherlands. We do not confine ourselves to manufacturing (with a breakdown into five branches), but also focus on agriculture and mining. In the last section of the paper the service sector productivity estimates of Burger and Smits are taken on board to evaluate productivity and income differentials for the four economies at large.[6]

Although we will refer to the "1910 benchmark" in the remainder of this paper, our estimates will refer to the years of 1909 and 1910 combined. These years were relatively stable years on the eve of World War I and the lion's share of our basic source material (i.e. censuses) refers to one of these two years, or even overlaps both years. We have conducted a sensitivity analysis for the UK/US comparison in which we based all data (prices, value added and employment) for manufacturing,

1 Ward and Devereux "Measuring British Decline" and "A Reply"; Broadberry "Relative Per Capita Income Levels", "Forging Ahead" and "How did the United States"; Broadberry and Irwin, "Labour productivity"
2 Maddison, *The World Economy: Historical Statistics*; de Vries and van der Woude, *Nederland 1500-1815*
3 Maddison, *Dynamic Forces*, chapter 2
4 O'Brien and Keyder, *Economic growth*
5 Broadberry and Irwin, "Labour productivity"
6 Burger and Smits, "A benchmark comparison"

agriculture and mining on 1910 and found a difference of just 0,3 percentage points in the productivity comparison. For the other countries these differences could of course be larger, but we opted for transparency (excluding a whole range of different price indices to overcome a one-year price gap) and take the potential estimation biases for granted.

Our main findings are that the gap between the US and the Western European countries, in terms of relative income per head of population, was smaller on the eve of World War I than suggested by previous studies. Compositional effects in general and the role of manufacturing and agriculture in particular, are instrumental in explaining these lower rates of convergence. Productivity differentials in services were considerably smaller than in the commodity producing industries however. Our estimates point at new insights as to in which period countries lost or gained their economic leadership. Whereas conventional estimates show that it is only around 1850 that Britain surpassed Dutch per capita income levels, our estimates date the take-over before 1820. Also the shift of economic leadership to the US occurred earlier than conventional estimates show. We date the take-over in the 1880s to 1890s and not in the early twentieth century. The total labour productivity comparison even reveals that already around 1850 the US had forged ahead. The US productivity lead is most obvious in the manufacturing sector, but huge productivity increases in services, and to a lesser extent, agriculture during the second half of the nineteenth century contribute most to the final take-over in GDP per capita.

The paper is structured as follows. Section two discusses our methodology and sources. In section three the main results are presented and interpreted. Section four discusses the analytical implications of our new PPP benchmark for the broader debates on convergence and divergence during the long nineteenth century. Section five offers a conclusion.

2. Methodology

From the 1940s onwards such notable economists as Simon Kuznets and Brian Mitchell in the US and Colin Clark in the UK have been active in the field of comparative economic performance of nations.[7] At present the best known comparisons of long-run productivity performance come from the work of Angus Maddison.[8] Part of the appeal of his approach is the wide temporal and spatial coverage of his data, the transparent methodology and his sole reliance on national time-series published by statistical offices, which makes it exceptionally well suited for research on comparative economic growth.

The Maddison time-series, or any of the long-term studies on economic growth for that matter, suffer from at least one major drawback: time-series projections do not adequately account for shifts in

7 Kuznets, S. *Modern Economic Growth*; Mitchell, B. R., *International Historical Statistics*; Clark, C. *The Conditions of Economic Progress*

8 Maddison, A. *Phases of Capitalist Development, Monitoring the World Economy* and *The World Economy: A Millennial Perspective*

sectoral output and changes in product prices. This becomes particularly apparent when time-series of different origins are projected from a certain benchmark-year into distant periods. In recent years, economic historians have stressed the need for new, more detailed, comparisons of welfare and productivity for earlier periods, particularly for the pre-World War 1 era.[9] As the debate between Broadberry versus Ward and Devereux in the *Journal of Economic History* has emphasized, direct benchmark comparisons between countries are a much wanted alternative for the long-span projections. And even if such direct benchmark comparisons do not produce a radically different view than the time-series, they are still valuable to confirm the reliability of the time-series we use.[10]

Ward and Devereux have constructed expenditure PPPs - in line with the methods applied by scholars such as Gilbert, Kravis and Maddison in the United Nations International Comparison Project - to obtain seven benchmark estimates of UK and US income per capita and output per worker between 1872 and 1930.[11] As the expenditure PPPs establish a direct link between comparative income levels and consumption possibilities, those estimates are particularly suited for international comparisons of income and living standards. However, for international comparisons of productivity and economic performance in general, a direct comparison of output at an industry level is preferable.[12] Such output figures can be converted using so-called industry-of-origin PPPs.

Whereas expenditure PPPs take the impact on consumer prices of imports, trade margins, transport costs and taxes into account, industry-of-origin PPPs are based on ex-factory prices excluding such factors. Industry-of-origin PPPs thus produce a more refined comparison of labour productivity levels. But more important, expenditure PPPs do not allow for a breakdown of labour productivity comparisons at a sector level to obtain a more in-depth view of the sources of growth and the effects of structural change. This is not to say that an industry-of-origin approach is a 'superior' methodology, we only indicate that the choice for expenditure or industry-of-origin PPPs primarily depends on one's research objective: living standards or economic performance?

The industry-of-origin method measures relative productivity at the industry level, by either estimating the quantities produced per worker (in tons, gallons, or units) directly, or by measuring the value of gross and net output by industry (in national currency), translated into a common currency with a sector-specific PPP-adjusted price ratio. The former method was pioneered by Rostas in 1935 and the latter by Paige and Bombach in 1950.[13] If all output is covered and the proper weights are applied, the two approaches provide in principle the same results. In practice, however, both methods yield different results because of differences in sampling methods, weighting schemes, and coverage of output. In the case of less than full coverage, the first method assumes that the actually measured

9 Prados de la Escosura "International Comparisons"; Fukao, K. et al. "Real GDP in Pre-War East Asia"; van Zanden, "Rich and Poor"
10 Ward and Devereux "Measuring British Decline" and "A Reply"; Broadberry "Relative Per Capita Income Levels", "Forging Ahead" and "How did the United States"; Broadberry and Irwin, "Labour productivity"
11 Ward and Devereux. "Measuring British Decline"; Maddison *The World Economy: A Millennial Perspective*
12 van Ark *International Comparisons of Output and Productivity*
13 Rostas, *Comparative Productivity*; Paige and Bombach, *A Comparison of National Output and Productivity*

quantity relatives of matched output items are representative for the unknown quantity relatives of unmatched output. The second method assumes that the price relatives of matched output are representative of the unknown price relatives of unmatched output. Recent studies by Fremdling, de Jong and Timmer as well as de Jong and Woltjer have underlined the practicability of the price comparison approach and have shown that this method provides a better representation of matched output for non-matched output than is the case with quantity ratios.[14]

For this study we have calculated average farm and factory gate prices from the values and quantities of the items reported in official agricultural, mining and manufacturing production censuses. These surveys contain detailed information on quantities and values of produced items, average prices, gross output, intermediate input and employment, enabling us to construct labour productivity comparisons bottom-up. For the United States we based our analysis on the *Thirteenth Census of the United States taken in the year 1910*, published by the Bureau of the Census of the U.S. Department of Commerce and the *Mineral Resources of the Unites States* published by the Department of the Interior as part of the United States Geological Survey. For the United Kingdom we relied primarily on the *First Census of Production of 1907* published under the census of production act of 1906. The data for the Netherlands was taken from the *Verslag over den Landbouw in Nederland 1910* and the *Statistiek van de voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* published by the Department of Agriculture (Departement van Landbouw) and the National Statistical Office (Centraal Bureau voor de Statistiek). For France we based our analysis on the *Evaluation de la Production* published by the Chambers of Commerce (1910) and the *Statistiques Administratives* (1912). In addition we relied on the *Annuaire Statistique de la France* for 1908 and the summary tables of 1966. A complete overview of sources used can be found in Appendix A.

From all the product specific quantities and values we calculated unit values (uv), which are essentially the average value of a single unit of a commodity or group of similar commodities. A unit value of good ‘i’ can thus be derived by dividing the ex-factory output value (o) by the produced quantity (q) for that good, as shown in equation (1) below. In a bilateral comparison, the ratio of two unit values, the so-called unit value ratio (UVR), represents the relative producer price of the matched product. Equation (2) shows a UVR with country ‘A’ taken as the base country, which in our case is always the US. The output details of the census reports allowed us to match between 40 and 100 production items per country pair. Appendix B contains a list of covered items and their share in total output.

14 Fremdling, de Jong and Timmer “British and German Manufacturing”; Fremdling, de Jong and Timmer “Censuses Compared”; de Jong and Woltjer "A Comparison of Real Output and Productivity”

$$uv_i = \frac{o_i}{q_i} \tag{1}$$

$$UVR_i^{BA} = \frac{uv_i^B}{uv_i^A} \tag{2}$$

The UVRs are aggregated to obtain Gross Output Purchasing Power Parities.[15] The UVR's are then weighted several times using a so-called *stratified sampling approach*; first according to their share in the total value of matched products for the industry, then according to the industry share in the branch and finally according to the branch share in the manufacturing sector. In all cases two sets of indices were constructed; one using the base country prices and quantity weights ($w_{ij}^{A(A)}$) and one using the base country prices and non-base country quantities $w_{ij}^{A(B)}$). [16] In a bilateral comparison, when one assumes country 'A' to be the base country, the first PPP presented below in equation (3) is an index of the Laspeyres type, whereas the weights of the (non-base) country 'B' would have to be used for constructing a Paasche index (4). It is worth noting that generally Laspeyres PPPs will be higher than Paasche PPPs.[17] Throughout this study we use the geometric average of the Laspeyres and Paasche indices, the so-called Fisher index, as the currency conversion factor for our productivity comparisons.

$$PPP_j^{BA(A)} = \sum_{i=1}^{I_j,GO} w_{ij}^{A(A)} UVR_{ij}^{BA} \tag{3}$$

$$PPP_j^{BA(B)} = \sum_{i=1}^{I_j,GO} w_{ij}^{A(B)} UVR_{ij}^{BA} \tag{4}$$

15 For convenience we will refer to the Gross Output Purchasing Power Parities (GOPPP) as Purchasing Power Parities (PPP) throughout the paper.

16 A detailed description of the *stratified sampling approach* is provided by Timmer *The Dynamics of Asian Manufacturing*, pp. 26-30. In the present study the minimum number of matches for a sample to be accepted was 2 with a maximum coefficient of variation of 20 percent. The coefficient of variation is given by the expression below; where Ij is the number of matches for industry 'j'; wij the relative weight of product 'i' in the total value of production of industry 'j'; UVRij the unit value ratio of product 'i'; and UVRj the weighted average unit value ratio, or purchasing power parity, of industry 'j'.

$$\mathrm{var}\left[UVR_j\right] = \sqrt{\frac{1}{I_j - 1}\sum_{i=1}^{Ij} w_{ij} \cdot \ln\left(UVR_{ij} / \overline{UVR}_j\right)^2 \cdot \left(1 - \sum_{i=1}^{Ij} w_{ij}\right)}$$

17 Kravis refers to this phenomenon as the "Gerschenkron effect", which arises from the fact that each country's gross output structure adapts itself to the country's own price structure; where gross output tends to be large when prices are low and vice versa. Hence, valuation of gross output by a set of foreign quantities tends to inflate its aggregate value. See Kravis "A Survey of International Comparisons of Productivity"

Business cycle and capacity utilization effects can have a significant influence on the measurement of output and productivity levels for a particular year. However, as the countries included were all in a comparable state of economic growth at that time, we believe that for our purposes the years 1909/1910 are suitable for a fair comparison,.[18] In addition, the detailed source data required for this type of analysis is largely available for these years, or some years sufficiently close (see Appendix A). As already mentioned above, the censuses do not refer to exactly the same year and they are not completely comparable in coverage. The British census of 1907, the American census of 1910 and the Dutch census of 1913 provide an almost complete coverage of agriculture, mining and manufacturing. The two French censuses for 1910/12 and 1912/13 consist of several investigations for single industries and do not provide the same coverage as for the other countries. Nonetheless, additional sources for France, such as the studies of Markovitch, Toutain and Dormois enabled us to apply our PPP estimates to value added estimates at a sector and total economy level.[19] Where necessary we used existing price indices to extrapolate price data backwards or forwards to our 1909/10 benchmark.

3 Main results

This section discusses our main results. Table 1 presents our PPP estimates for agriculture, mining, manufacturing and the combined PPP for agriculture and industry, including utilities and construction. Note that the PPPs are based on 1909 prices in the case of manufacturing and 1910 prices in the case of agriculture and mining. The first row gives the 1910 exchange rate (which was identical to 1909).

Table 1 demonstrates that there existed substantial relative price differences between industries in this period. In the three Western European countries the mining products, which primarily consisted of coal, were rather expensive as compared to the US. In France agricultural products were also quite expensive, especially when compared to the relative price level of manufactured goods. In the UK this was the other way around: agricultural products were comparatively cheap, while the price level of manufactures was higher, though still a little below the official exchange rate. In the Netherlands the differences between the producers' prices of agricultural and manufactured commodities were relatively small.

[18] See de Jong and Woltjer "A Comparison of Real Output and Productivity" for an elaborate discussion of the business cycle and capacity utilization effects and a sensitivity analysis for the interwar period.

19 Markovitch, "Le produit physique"; Toutain, "Le produit intérieur"; Dormois, *the Elusive French Productivity Lag*

Table 1: Fisher PPPs at industry level: UK, Netherlands and France (1909/10 US $)

	UK/US (£/$)	NL/US (Dfl/$)	France/US (Ffr/$)
Exchange rate	0.21	2.49	5.21
Agriculture PPP	0.14	2.11	7.95
Mining PPP	0.34	4.87	7.55
Manufacturing PPP	0.19	2.40	4.99
Industry PPP	0.21	2.35	5.36
Total Agriculture & Industry PPP	0.19	2.26	6.69

Sources: See Appendix A.

How do our PPP estimates compare to other existing estimates? O'Brien and Keyder constructed a total economy PPP for their Anglo-French comparison of nineteenth century economic development. Their PPP is based on a selection of six representative commodities, e.g. beef, wheat, coal, flour, pig iron and cotton yarn. For the period 1905-1913 their France-UK PPP was estimated at 29.04 (using French output weights) and 29.76 (UK weights), which compares to our Fisher PPP estimate of 35,2 French francs per British Pound (matched via the US benchmark).[20] In an unpublished working paper Burger presented industry PPPs for the US, Netherlands and France using the UK as base country. Transforming his PPPs to US dollar based estimates we find a comparable result for the UK-US comparison: Burger reported 0,19 and we find 0,21£ per US$. For the Netherlands and France the differences are larger, around 15% (2,03 to 2,35 for the Netherlands and 4,67 to 5,36 for France).[21]

A further decomposition of the manufacturing sector offers additional insights in the price structure of these four economies. Our manufacturing PPPs have been built up from five underlying branch PPPs, including 1) metals and machinery, 2) textiles, leather and clothing, 3) food, drink and tobacco, 4) chemicals and 5) miscellaneous industries. Appendix B presents an overview of all the products matched per branch. Table 2 presents the PPPs.

Table 2 shows that the relative price differences across branches were large, especially in the Netherlands and France. Such price differences testify to a specific pattern of industrial specialisation which will become even more evident when we discuss the labour productivity comparisons further below. The Dutch case offers the best example. Considering the official exchange rate of 2,49 Dutch Guilders per US Dollar (see table 1) it appears that the Dutch food and textile trades managed to produce at competitive price levels, while the chemical and metal trades were way too expensive to be internationally competitive.[22] The observed price differences within the manufacturing sector have another important implication as well: they show that the use of a uniform currency converter, such as the official exchange rate, will not generate accurate productivity comparisons at a branch level since

20 O'Brien and Keyder, *Economic Growth*, pp. 40-47
21 Burger, *A Five-Country Comparison*, p. 5
22 de Jonge, *De Industrialisatie in Nederland*; Griffiths, *Industrial Retardation*, Smits et al., *Dutch GNP*

it rules out the possibility of intra-industry price differences. A stratified sampling approach takes these price differences into account when estimating PPPs at higher levels of sectoral aggregation.

Table 2: Fisher PPPs for five manufacturing branches: UK, Netherlands and France (1909 US $)

	UK/US (£/$)	NL/US (Dfl/$)	France/US (Ffr/$)
Metals & machinery	0.22	3.78	5.98
Textiles. leather & clothing	0.16	2.07	3.82
Food. drink & tobacco	0.19	2.02	6.21
Chemicals	0.21	3.51	7.48
Miscellaneous	0.19	1.81	5.39
Total Manufacturing	**0.19**	**2.40**	**4.99**

Sources: See Appendix A

What new light do these PPP estimates shed on international labour productivity comparisons? Table 3 presents the comparative labour productivity estimates (US = 100). Unsurprisingly, our results confirm the existence of a large Atlantic productivity gap in industry. This phenomenon has been extensively documented in the economic historical literature.[23] US industrial productivity levels were about 220% of the UK, 250% of France and 330% of the Netherlands. The intra-European productivity gaps were substantial as well, with the UK having a productivity lead of circa 80% over the Netherlands and France in agriculture and industry combined.

Table 3 further shows that the intra-European productivity gap was mainly driven by differences in agricultural productivity. The UK was more than twice as productive in agriculture as the Netherlands and almost three times as productive as France. In terms of industrial productivity the France-UK gap was far less dramatic.[24] Yet, the British economy was far ahead in terms of structural change, with a far more specialized agricultural sector. Around 1910 only 12% of the British labour force was engaged in agriculture, whereas in the Netherlands and the US this share was around 30% and in France 41%.

23 See for instance Paige and Bombach, *A Comparison of National Output and Productivity*; Rostas, *Comparative Productivity*; Gordon, *Two Centuries*'; Broadberry, *The Productivity Race*; Ward and Devereux, "Measuring British decline" and Field, "The Most Technologically Progressive" and "The Origins"
24 O'Brien and Keyder, *Economic Growth*, p. 146

Table 3: Comparative labour productivity estimates at industry level, ca. 1910 (US =100)

	UK/US	NL/US	France/US
Agriculture	90.8	43.0	33.2
Mining	41.6	10.0	39.9
Manufacturing	42.7	28.0	38.5
Industry	45.0	29.7	39.6
Total Agriculture & Industry	61.1	34.4	33.0

Sources: See Appendix A

So far our findings are in line with a large body of literature discussing the comparative advantages of the Western European economies during the late nineteenth and early twentieth century. It clarifies the French policy choice for agricultural protectionism in an era of globalisation.[25] It squares with the evolution of a specialised agro-commercial economy in the Netherlands in an era of rapid industrialisation in its neighbour countries.[26] It also underscores the Dutch economy as a coal-poor economy.[27] Considering the Anglo-French productivity comparison it is remarkable to see how close our estimates are to the 1978 results of O'Brien and Keyder, who estimated French industrial labour productivity in the years 1905-1913 at 94.2 to 97.7%.

The difference with the results reported by Dormois is larger though. Dormois finds French industrial productivity levels at 32.2.% of the US level in 1909, against 39.6% in our estimation.[28] Since we use Dormois' value added and employment estimates, this gap must be fully attributed to the different currency conversion methods applied.[29] Dormois uses the official exchange rate to convert French industrial labour productivity into US dollars of 1909, but as we have argued above, considering the large intra-industry price differences we find this approach difficult to defend.

Compared to the work on the Anglo-American productivity comparison the picture is mixed. Our UK/US manufacturing productivity level of 42.7% compares to the 49.5% reported by Broadberry and Irwin, andour agricultural productivity estimate of 90.8% is very close to their figure of 92.2%.[30] The differences in the manufacturing estimate are probably caused by the fact that Broadberry and Irwin use a 'quantity relatives' approach to estimate comparative productivity levels. The implicit PPPs that can be derived from this method are based on gross output (e.g. quantity per employee) of one product per branch. Our PPPs are based on value added instead of gross output figures and include a large number of commodities. In particular for the mining industry the different methods tend to produce different results. Broadberry and Irwin find UK productivity levels at 62.0% of the US while we find a level of 41.6%.

25 Knowles, *Economic development,* pp. 239-253
26 Griffiths, *Achterlijk, achter of anders?,* Van Zanden and van Riel, *Strictures of inheritance*
27 Gales, *Ondergronds bovengronds*
28 Dormois, *the Elusive French Productivity Lag,* pp. 7-8
29 A small part of the difference is due to the inclusion of mining in Dormois' comparison, which we treat separately in this paper.
30 Broadberry and Irwin, "Labor productivity", table 1, p.261

Table 4 presents our labour productivity comparisons for the five manufacturing branches. As argued above, the interesting part of such a detailed analysis relates to the substantial productivity differentials that can be observed between the various branches. Especially in the Netherlands the comparative productivity gap between the heavy industries such as the metal and chemical trades and the lighter industries such as textiles and foodstuffs loomed large. Labour productivity in the food producing industries was, on average and relative to the US, more than twice as high as in the metal industries and even three times as high as in the chemical industries. It reveals the defectsof the Dutch industrial sector during the nineteenth century: a complete absence of competitive heavy industries.

Table 4: Comparative labour productivity in five manufacturing branches, ca. 1910: UK, The Netherlands and France (US = 100)

	UK/US	NL/US	France/US
Metals & machinery	37.4	17.4	41.4
Textiles. leather & clothing	52.2	29.2	46.0
Food. drink & tobacco	51.7	32.1	32.0
Chemicals	42.5	7.5	26.4
Miscellaneous	44.1	38.4	44.6
Total Manufacturing	**42.7**	**28.0**	**38.5**

Sources: See Appendix A

Dutch manufacturing was based on the linkages it could establish with the specialised agricultural sector (food industries) and the colonial relationships with the Dutch Indies (textiles).[31] Only during the interwar years did the Dutch manufacturing sector experience a strong phase of catch-up growth and diversification enhanced by the rapid adoption of electricity.[32] The British figures also demonstrate a comparative advantage for the textile and food industries and a disadvantage in metals and chemicals vis-à-vis the US, but the inter-branch differences are much less pronounced than in the Netherlands. In France the chemical industry was comparatively weak, about 26% of the US level, and the textile industries did comparatively well, about 46% of the US level.

A more detailed analysis of the productivity gap between the US and the three Western European countries in manufacturing also sheds new light on the impact of 'structural' and 'compositional' differences. Standard economic theory predicts that in an open economy setting countries tend to specialise in activities in which they have a comparative advantage. In the hypothetical case that the employment structure of the UK, Netherlands and France would have been exactly identical to the US, 'compositional' differences are zero and would not affect the aggregate manufacturing productivity gap. But this was obviously not the case. In France and the UK the textile industry employed respectively 46% and 37% of the manufacturing labour force against 26% in the

31 Smits et al., *Dutch GNP*; Van Zanden and van Riel, *Strictures of Inheritance*

32 The most comprehensive account available of this process is offered by the De Jong, *Catching up twice*

US. And while the US food industry employed only 11%, in the Netherlands this share was 35% of the manufacturing workforce.

To find out how large the effects of industrial specialisation on the productivity comparison are, table 5 repeats the manufacturing productivity comparison of table 4 in the first column, based on the geometric average of the employment distribution in the base economy and the comparison economy (Fisher). The consecutive columns report the comparative productivity levels using the employment distribution of the US (Laspeyres) and the comparison country (Paasche).

Table 5: The effects of the employment structure on comparative labour productivity in manufacturing: UK, Netherlands, France versus the US, ca. 1910

	UK/US	NL/US	France/US
Fisher (Geometric average)	42.7	28.0	38.5
Laspeyres (US weights)	41.8	24.0	37.9
Paasche (Own country weights)	43.6	32.7	39.2

Sources: See Appendix A

Table 5 indeed shows that all three countries reveal higher productivity levels vis-à-vis the US when we use their own employment distribution. It can thus be argued that, again in relation to the US, the Western European economies specialised in a 'rational' way. Given the tiny differences observed for the UK and France we should not make too much of this though. More interesting, however, is the finding that the compositional effects on labour productivity in the notably smaller and more open economy of the Netherlands were clearly apparent: using a Laspeyres or Paasche PPP makes a difference of 8,7% in estimated manufacturing productivity. This again supports the view that the industrialisation process in the Netherlands before World War I was based on developing some niches, rather than an encompassing industrial sector. We will see in the next section that missing the boat during the first and second industrial revolutions put the Dutch economy in a much more backward position than existing comparative estimates of GDP per capita suggest, despite its strong performance in services.

4. Total Economy and Long-Run Implications

Until now this paper focused on agriculture, mining and industry- the goods producing sectors of the economy. However, in our attempts to chart the relative strength of the various economies on the eve of World War I, also services need to be taken into account. Table 6 summarizes the main findings

from section four and includes estimates for services made by Burger and Smits.[33] These data are aggregated (again according to the stratified sampling approach) in order to get an idea of international differences in economy-wide labour productivity as well as variations in GDP per capita.

Table 6: Relative labour productivity by industry and relative levels of GDP per capita in the UK, the Netherlands and France, ca. 1910 (US=100)

	UK/US	NL/US	France/US
Agriculture and industry	61	34	33
Services	89	83	68
Economy-wide labour productivity	76	51	43
GDP per capita	82	52	56

Sources: For agriculture and industry see section 3 of this paper. Estimates for services are taken from Burger and Smits, "A benchmark comparison".

Burger and Smits constructed their service sector productivity estimates by calculating unit value ratios (based on an industry-of-origin approach) for transport (railways), communication, trade, government and other (personal) services. These unit value ratios were based on the relative prices of transportation (freight rates as well as tariffs for passengers), the prices of postal items, telegrams and telephone calls as well as average trade margins for the trade sector. Burger and Smits used two different sets of estimates for government and other (personal) services. In one set the differences in real wages were used as an indication of comparative levels of labour productivity for these types of services, assuming perfect market conditions. In the second set of estimates these two branches within the service sector were set at 100, assuming no international productivity differences. It seems that the overall comparative productivity levels for the service sector at large are hardly affected by these different methods of estimation. Although much more work needs to be done in order to better integrate the service sector in existing total economy productivity estimates, we have confidence in the service sector estimates we use given the close correspondence of our estimation of the comparative UK/US productivity rate (89%) with the figure of 84% reported by Broadberry and Irwin.

The main conclusion that can be drawn from table 6 is that international disparities in productivity in the service sector were much lower than they were in the goods-producing sectors. Including services in the total economy comparison thus results in a much higher degree of convergence around 1910 than suggested by the combined estimates for agriculture and industry. Including services boosts the economy-wide productivity levels of France with 10, of the UK with 15 and of the Netherland even with 17 percentage points versus the US.

Table 7 compares our new results with previous attempts to measure economy-wide income differences between the four countries in terms of their GDP per capita. Our industry-of-origin

33 Burger and Smits, "A benchmark comparison"

estimates are compared with expenditure-based productivity calculations by Ward and Devereux. Besides, for the UK also the Broadberry and Irwin estimates (both industry-of-origin and expenditure based calculations) are included. Moreover, the estimates are compared with the various versions of the Maddison dataset expressed in 1970, 1985 and 1990 dollars.

Table 7: Different approaches to estimate comparative levels of GDP per capita: UK, The Netherlands, France and the US in 1905 and 1909/10 (US=100 in 1905 and 1909/10)

Author	Approach	Year	UK/US	NL/US	Fr/US
Our estimates	Industry of origin PPP	1909/10	82	52	56
Ward & Devereux	Expenditure PPP	1905	82/92	63	67
Broadberry & Irwin	Quantity relatives	1909/11	89		
Broadberry & Irwin	Expenditure PPP	1909/11	95		
Maddison	1990 international dollars	1910	93	76	60
Maddison	1985 international dollars	1910	80	65	55
Maddison	1970 international dollars	1910	79	68	64

Sources: Ward and Devereux, "New perspectives" (92, 63 and 67) and "Measuring British decline" (82); Broadberry and Irwin, "Labour productivity"; Maddison, *Phases of capitalist development* (1970$); Maddison, *Dynamic Forces* (1980$) and Maddison, *The world economy* (1990$)

For all three Western European countries our GDP per capita estimates are lower than hitherto suggested in literature. For France the differences are between 0 and 11%. For the UK our estimate amounts to 82%, which is 7-13% below the Broadberry and Irwin estimate and is also lower than the more recent Ward and Devereux figure.[34] It is interesting to notice that our estimates come rather close to the older estimates of Maddison, expressed in 1985 or 1970 dollars. This similarity seems to suggest that the earlier benchmarks of international dollars reflect the actual price differences around 1910 better than the later benchmarks. However, the largest differences were recorded for the Netherlands. The most recent Maddison data point at an income level of 76% of that of the United States. The expenditure based estimate of Ward and Devereux stands much lower at 63% and our new industry-of-origin figure measures a relative income level of only 52%. Also here the Maddison estimates expressed in 1985 and 1970 dollars are lower than his most recent estimates and therefore closer to our new benchmark estimate.

The remainder of this section will deal with the comparative productivity performance of the three countries which were technology and productivity leaders from the seventeenth century onwards, i.e. the Netherlands, the United Kingdom and the United States. First we will focus on the debate concerning the timing of the economic take-over of Britain by the United States. Next we discuss the relative decline of the Dutch economy and the overtaking by the United Kingdom.

34 This estimate (92' is taken from a yet unpublished working paper presented at the International Economic History Congress 2006, in Helsinki. We would like to thank the authors for permission to cite their paper. See Ward and Devereux, "New perspectives"

The UK-US income and productivity differentials

The discussion on the timing of the economic overtaking of the United States during the nineteenth and early twentieth century has been quite intense. In his 1997 and 1998 articles Broadberry argued that the United States overtook the United Kingdom in the 1900s.[35] In 2003 this view has been contested by Ward and Devereux who, on the basis of brand-new expenditure PPP estimates, maintained that already in the 1870s the relative level of GDP per capita of the US was higher than that of the UK.[36] Prados de la Escosura even argued that the US was already ahead of the UK in the first half of the nineteenth century.[37] However, in subsequent publications Broadberry and Broadberry and Irwin maintained their view that the economic overtaking of the United States cannot be dated as early as Ward and Devereux suggest.[38]

A backwards projection of our benchmark estimates on existing time-series yields some interesting conclusions. Table 8 summarizes the main findings on changes in relative income levels. First of all, contrary to the data presented by Ward and Devereux, which point at a more-or-less constant income differential between the UK and the US in the period 1870-1910, we observe a clear downward trend in the relative income level of the UK. Also our data point at a UK income level which is still slightly above that of the US in the 1890s. Yet, the backwards extrapolation of our estimates points at a substantially smaller income lead of the UK in the period 1850-1870: 14-16% as compared to 46-47% by Broadberry and Irwin.

The differences between Broadberry and Irwin's time-series and ours can only partly be explained from our new 1910 benchmark estimate. Of course our lower 1910 relative income level results in a lower estimation for earlier time-periods, but in order to make a fair comparison, we extrapolated our 1910 productivity benchmark backwards using the Broadberry and Irwin time-series (see column 3). Around 1850 the UK income lead seems to be lower than the Broadberry-Irwin data suggest, with an income lead of 36% against 47% in their original estimates.

Table 8: Relative income levels UK/US, 1849/51-1909/11 (US=100)

	Our estimates	Broadberry & Irwin	Broadberry & Irwin Our 1910 level	Ward & Devereux 2004
1849/51	114	147	136	--
1869/71	116	146	135	86 (1872)
1889/91	105	119	110	79 (1890)
1909/11	82	89	82	82 (1905)

Source: See table 5 and Broadberry and Irwin, "Labour productivity", Ward and Devereux, "Relative UK/US output reconsidered" and Maddison, http://www.ggdc.net/Maddison/ (version March 2009)

35 Broadberry, "Forging ahead, falling behind and catching up"; Broadberry, "How did the United States and Germany overtake Britain?"

36 Ward and Devereux, "Measuring British decline"

37 Prados de la Escosura, "International comparisons of real product, 1820-1990"

38 Broadberry, 'Relative per capita income differentials'; Broadberry and Irwin, 'Labour productivity in the United States and the United Kingdom'.

Hence, the second major source of differences with the Broadberry and Irwin data stems from the time-series we used for our backward extrapolation. Here we followed the choices made by Maddison.[39] His series should be preferred over the ones used by Broadberry and Irwin for a number of reasons. First of all, Maddison makes a correction for Ireland which is not included in the regular pre-1855 series which refer to Great Britain and not to the United Kingdom.[40] Such a correction has not been made in the Broadberry and Irwin paper, which may result in a bias as the Irish income levels were substantially lower than those elsewhere in the UK.

More important, however, are the differences in the time-series for the United States. Broadberry and Irwin make extensive use of the series by Balke and Gordon. Maddison, however, only uses Balke and Gordon for the period 1869-1890.[41] He uses Kendrick's figures for the post 1890 period and bases his series for 1840-1869 on the work of Gallman.[42] We follow Maddison in this respect, because our 1910 benchmark calculations indicate that Balke and Gordon underestimate nominal GDP for the years 1909 and 1910. If we take their nominal GDP estimate and subtract the value added for agriculture and manufacturing (as we calculated on the basis of census material) the remaining GDP share of services appears much smaller than conventional studies, such as the *Historical Statistics of the United States*, report. In case we would use the Balke and Gordon nominal GDP estimate, services would amount to ca. 42% of GDP which is much lower than the percentage of 55% (!) that is reported in the Historical Statistics.[43] This has serious implications for the backwards extrapolations, as the service sector witnessed much more labour productivity growth in the US than it did in the UK.

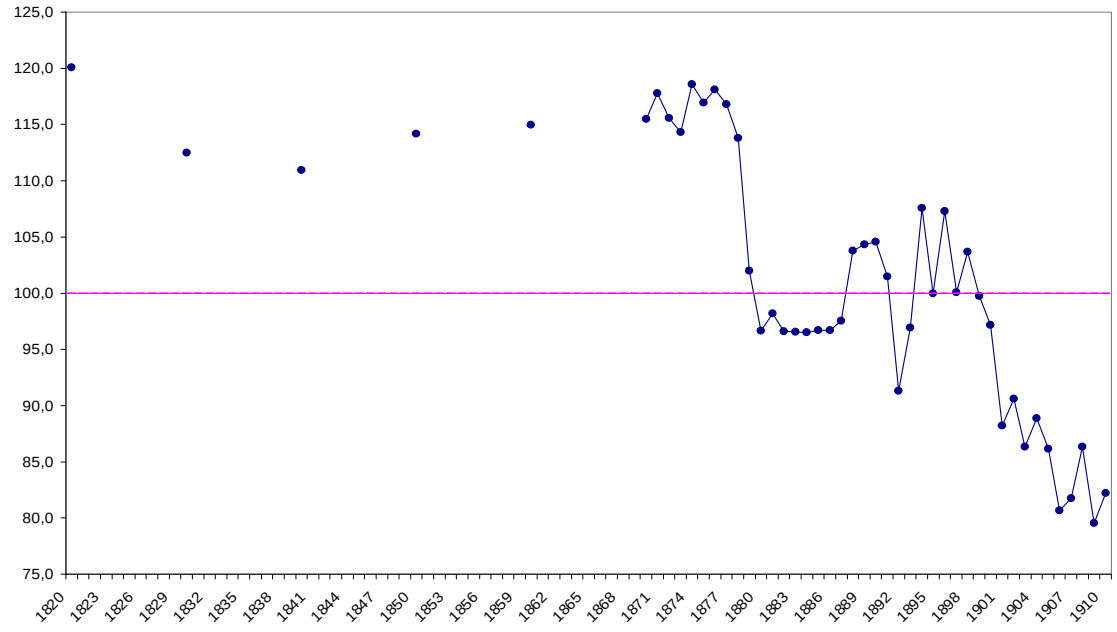
Figure 1 shows that it also matters whether one focuses on comparing benchmark years or annual time-series. The benchmark years reported in table 8 suggest that the take-over should be dated somewhere between 1890 and 1910. But a time-series analysis reveals that the take-over in GDP per capita should be dated earlier, around the two decades between 1879 and 1899. Figure 1 shows that the pace of economic growth in the US and UK in the final two decades of the nineteenth century was quite comparable. Especially during the 1870s and 1900s the US grew much faster than the UK.

From the 1850s onwards we have more detailed data on comparative labour productivity at our disposal, which might enable us to pin-point which industries were responsible for the forging ahead or lagging behind of the economies we investigated. Table 9 focuses on the UK-US productivity differentials at the industry level. Here we compare our new estimates with the work of Ward and Devereux as well as Broadberry and Irwin. Of course these are tentative calculations. Especially for services, much more detailed research needs to be done into time-series for output and labour, as has

39 Maddison, *Dynamic Forces*, appendix A
40 This correction stems from the work of Phyllis Deane, "The New Estimates of Gross National Product", which Maddison used for his time-series for the period 1830-1855 (p. 106). The post-1855 period is based on Feinstein, *National Income*, pp. T18-20.
41 Balke and Gordon, "The estimation of prewar gross national product"
42 Kendrick, *Productivity trends* and Gallman, "Gross National Product"
43 *Historical Statics of the United States*, F216-225, p. 238.

already been indicated by Burger and Smits.[44] Our US series are derived by extrapolating our 1910 benchmark estimates backwards using the Kendrick series for the period 1870-1910, and the work of Gallman and Gallman and Weiss for earlier years. For the UK we used Feinstein back to 1855 and Lewis for the 1850 benchmark (see further source description below table 9).

Figure 1: UK/US GDP per capita, 1820-1913 (US=100)



Source: Table 8 and Maddison, http://www.ggdc.net/Maddison/ (version March 2009)

The estimates on comparative labour productivity reveal that already midway the nineteenth century the UK had lost its leading position. These data seem to give some support to Ward and Devereux, who argued that the UK lost its position as a productivity leader much earlier than around 1900, as suggested by Broadberry and Irwin. However, our new series also show a relative decline in the comparative productivity performance of the UK as is indicated by Broadberry and Irwin. This finding is in sharp contrast with the estimates presented by Ward and Devereux, which point at a more-or-less stable comparative labour productivity of the UK versus the US in the post 1870 period. As Broadberry and Irwin have pointed out, the large gap between the relative UK/US income levels and the relative productivity levels is the result of considerably lower labour force participation rates in the US (in 1850 ca. 35% in the US and 43% in the UK).

The fact that the UK maintains its leading position for such a long time according to the Broadberry and Irving estimates, can be explained by the high "initial" level of labour productivity midway the nineteenth century. Their estimate of the comparative labour productivity of the UK is much higher than ours. This difference can largely be ascribed to their high levels of labour

44 Burger and Smits, "A benchmark comparison", pp. 136-139.

productivity in mining, construction and services. Especially services seem to play a large role in the overall deteriorating comparative productivity performance of the UK economy. Not only is there the risk that the labour productivity in UK services is overestimated by Broadberry and Irwin around 1850-1870. But besides, they underestimate the share of services in US GDP for the post 1870 period. This results in an overestimation of the UK's overall comparative productivity performance in the Broadberry-Irwin estimates.

Table 9: Comparative labour productivity by industry UK/US according to different authors, ca. 1850-1910 (US=100)

	Agriculture	Mining	Manufact.	Construction	Total Industry	Transport	Trade	Total Services	Total economy
					Broadberry & Irwin				
1849/51	101	146	44	187	61			153	111
1859/61	100	165	52	129	65			137	105
1869/71	108	98	55	156	69	113	144	129	106
1879/81	96	101	59	107	68	88	93	97	102
1889/91	103	92	52	91	60	68	104	96	100
1899/01	89	68	51	106	59	50	94	86	87
1909/11	92	62	50	75	54	52	84	84	80
					Ward & Devereux				
1849/51									
1859/61									
1869/71	52	97	55	78		75	71		
1879/81									
1889/91	61	92	52	63		58	64		
1899/01									
1909/11	52	62	49	40		53	63		
					Our estimates				
1849/51	93	122	45	117	58	225		142	96
1859/61	99	130	37	126	50	109		126	95
1869/71	99	64	51	122	61	140	180	124	85
1879/81	88	67	55	83	61	117	117	102	78
1889/91	96	61	48	69	54	87	131	126	88
1899/01	82	47	49	86	55	65	122	99	82
1909/11	91	42	43	48	45	65	104	89	76

Sources: Broadberry and Irwin, "Labour productivity"; Ward and Devereux, "Relative UK/US output reconsidered"; Our estimates: US and UK total economy value added from Maddison, http://www.ggdc.net/Maddison/ (version March 2009). US value added by industry from Kendrick, *Productivity trends* (table A-IV, p. 302-3) for 1869-1911; Galmann "Gross national product in the US" (table A-1, p. 43) and Galmann and Weiss, "The service industries" (table 3 and A-1, p. 292 and 306) for 1849-1861. US employment by industry from Kendrick (table A-VII, p. 308) for 1869-1911; Lebergott, "Labor force" (table 1, p.118), Galmann and Weiss (table A-12, p. 333) for 1849-1861. UK value added by industry from Feinstein, *National Income* (tables 51, 53 and 54, pp. T) for 1859-1911; Lewis, *Growth and Fluctuations* (table A.3, pp. 260-1) for 1849-1851. UK employment by industry from Feinstein (table 57 and 61, pp. T125-6 and T131) for 1859-1911, Lewis (1978, Table A.4, p. 265) for 1849-51.

The Dutch-UK income and productivity differentials

The 1910 benchmark also sheds a new light on the comparative productivity performance of the UK versus the Dutch Republic/The Netherlands. According to the Maddison data it was only somewhere in the 1860s that the UK overtook the Netherlands in terms of income per head of population. The backwards extrapolation of our new benchmark provides a long-run view in comparative economic strength which we believe is more plausible. Table 10 shows the differences.

Table 10: Long-run changes in relative levels of GDP per capita in the Dutch Republic/the Netherlands, 1700-1913 (UK=100)

	Maddison	Our estimates
1700	170	131
1820	108	83
1850	102	78
1870	86	67
1890	83	64
1910	82	63

Source: Table 6. The Maddison data are from http://www.ggdc.net/Maddison/ (version March 2009)

In the early eighteenth century the Dutch Republic still enjoyed higher levels of income per head of population than the United Kingdom. However, we find that the income lead of the Dutch was much smaller (31% against 70%) than suggested by Maddison. Besides, a backwards extrapolation of our time-series, based on Maddison's time series, indicates that already before the 1820s the British economy had forged ahead in terms of relative income levels. This result is much more in line with the Dutch historiography claiming that output levels plummeted in the Dutch Republic during the last quarter of the eighteenth century. Van Zanden and van Riel label the Dutch economy and its underlying technological and institutional basis as 'obsolete' in this period. [45] For similar reasons de Vries and van der Woude locate the take-over of England (note: not the UK!) around 1790.[46]

Data on comparative labour productivity at an industry level may shed more light on the change in economic leadership. First of all, the figures for Dutch manufacturing in table 11 point out the huge 'productivity problem' in this sector of the economy. The levels of comparative productivity in manufacturing were rather low around 1850 and they hardly showed any increase in the period up to 1910. The poor productivity performance can be explained from the slow and limited adoption of steam power in Dutch manufacturing.[47] Traditional sources of energy, like wind, water and horsepower prevailed. These technologies had remained unchanged from the seventeenth century until about the 1850s.[48]

45 Van Zanden and van Riel, *Strictures of Inheritance*, pp. 20-32
46 De Vries and van der Woude, *Nederland 1500-1815*, p. 814
47 Smits, "The determinants", pp. 239-240
48 Jansen, *De industriële ontwikkeling*

Table 11a: Comparative levels of labour productivity in the Netherlands versus the UK, 1850-1910 (UK=100)

	Agriculture	Manufact.	Total Industry	Transport	Trade	Total Services
1849/51	85	55	56	65	130	92
1859/61	60	48	48	77	110	86
1869/71	61	46	45	73	123	91
1879/81	54	59	48	66	109	90
1889/91	44	66	63	76	126	95
1899/01	50	61	59	92	113	93
1909/11	47	66	66	102	118	93

Table 11b: Comparative levels of labour productivity in the Netherlands versus the US, 1850-1910 (US=100)

	Agriculture	Manufact.	Total Industry	Transport	Trade	Total Services
1849/51	166	33	45	135		134
1859/61	141	24	32	76		108
1869/71	135	34	40	105	174	115
1879/81	92	47	52	63	108	93
1889/91	105	48	52	65	138	135
1899/01	87	45	49	59	117	99
1909/11	91	43	45	65	104	89

Sources: Tables 6, 9 and Smits et al., *Dutch GNP*

The reason for the limited use of steam power was two-fold. First, levels of aggregate domestic demand were so low that traditional types of production (i.e. based on the use of wind- and water power) retained their cost advantage over the introduction of steam engines characterised by high initial fixed costs.[49] But even more important, in the industries in which the Dutch economy had strongly specialised such as the food-processing industries, the use of steam power proved difficult for technological reasons as well as a lack of feasible scale economies.[50]

Other branches of the economy did much better. Midway the nineteenth century the Dutch level of labour productivity in agriculture was at 85% of the British level. And in services this figure was even as high as 92% (especially due to the strong performance of the Dutch trade sector, which had a level of labour productivity which was 30% higher than in the UK). Of course, agriculture and services had been the two main pillars on which the economy of the Dutch Republic had been built in its Golden Age.

Both of these branches witnessed a steady decline in comparative productivity rates vis-à-vis the United States as well as the United Kingdom throughout the second half of the nineteenth century

49 Smits, "The determinants", 235-238; Horlings and Smits point at the importance of demand constraints in the Dutch economy and its impact on the timing of modern economic growth, see: Horlings and Smits, "Private consumer expenditure"

50 Lintsen et al, *Geschiedenis van de Techniek*, vol. 1, pp. 269-271

however. For agriculture the declining levels of comparative labour productivity can at least partly be explained from the already high levels of productivity which were attained in the early nineteenth century: Dutch agriculture had already reached its efficiency frontier. [51] The modern features of Dutch agriculture are often mentioned in Dutch historiography. The agricultural sector became strongly commercialised and export-oriented from the late Middle Ages onwards. De Vries explains the high levels of productivity in farming in the early modern period in terms of a deliberate process of specialisation.[52] The scope for further increases in labour productivity was quite limited, as the slow increases in agricultural output per worker indeed show.[53]

For services the explanation of a poor comparative productivity performance in the second half of the nineteenth century is less straightforward. Also in this case the levels of comparative productivity were initially quite high. But these high levels of labour productivity cannot be ascribed to the 'modern' or efficient features of the Dutch service sector, on the contrary. They were rather a symptom of the pre-modern (and sometimes even archaic) way in which above all the domestic trade and transport industries were organised. Until about 1870 trade was organised in a rather hierarchic way; there existed a system of regional, national and international staple markets that maintained close relationships. The main aim of these staple markets was to keep stocks up so as to be able to supply goods to the hinterland whenever necessary. In an age of limited means of transport and communication this was an efficient way to make supply meet demand as well as possible. Within this intricate trade system with its many middlemen who all enjoyed monopolies on their specific types of trade, huge trade margins could be realised.

The same applied for the domestic transport system which until the first half of the nineteenth century was still bound by strict rules and under the control of city councils which guaranteed entrepreneurs in the shipping high freight rates.[54] All in all, the specific institutions built around the trade and transport sector ensured people working in services with high incomes.

From the 1870s onwards the comparative Dutch labour productivity in trade and transport showed a significant decline as can be seen from table 11. Especially in the last quarter of the nineteenth century, when due to infrastructural improvements and better communication technologies there was less need for intermediate trade, more direct trade relations between producers and consumers were established. This resulted in declining trade margins, reflected in lower levels of labour productivity for the trade sector. For the transport sector the same type of development can be discerned. It was only from the 1890s onwards, when the 'old institutions' of the Dutch Republic had been broken down, that a new phase of productivity growth started in trade and transport. But in this

51 Van Zanden, "The first green revolution", p. 219.
52 De Vries, *The rural Dutch economy*
53 Smits, "Technological change", p. 100. However, huge gains were made in terms of land productivity, as land became the scarcest factor of production. Output per hectare showed a strong increase throughout the second half of the nineteenth century. Even though levels of labour productivity did not increase that much, around 1910 the Dutch farmers were among the most productive in terms of land productivity.
54 Smits, *Economic growth*, chapter 6.

case, productivity growth was not boosted by protection and monopolistic pricing, but by organisational change and technological innovation (especially in the transport sector). Still, until the First World War these changes did not result in a clear catching-up of comparative labour productivity in Dutch services.

5. Conclusion

This study has offered a new PPP benchmark for agriculture, mining and five manufacturing branches in the US, UK, France and the Netherlands around 1910. The PPPs were constructed using an industry-of-origin approach (section 2) to assess comparative levels of labour productivity at a sector level (section 3). The estimates were subsequently used to build up a comparison of total labour productivity and GDP per capita, including estimates of comparative service sector productivity from Burger and Smits (section 4). In terms of its empirical contribution this study is the first we know of to have systematically applied an industry-of-origin approach to an international comparison of labour productivity between Western Europe and the United States for a pre-World War I benchmark year, including all sectors of the economy. It complements the extensive work that has been undertaken on the UK-US comparison and it has cleared some uncovered terrain for the Netherlands and France.

The paper has made a deliberate distinction between a presentation of the main results (in section 3), focusing on the productivity estimates for agriculture and industry between the four countries, and the total economy and long run implications (in section 4) which are of a more tentative nature. The main results demonstrate that the Atlantic productivity gap around 1910 extended to nearly all goods producing sectors of the economy, with the important exception of British agriculture. Industrial productivity in the UK stood at ca. 45% of the US level (inverted: 220%); in France it was about 40% (inverted: 250%) and in the Netherlands even just about 30% (inverted: 333%). For agriculture the figures for the Netherlands (43%) and France (33%) are of a similar order of magnitude, although the Dutch outperformed the French in this sector. In the UK, however, agricultural productivity kept pace with the US and this is the main reason for the appearance of a European productivity gap next to the Atlantic divide. The labour efficiency of British agriculture shows that differences in the sector structure of the economy play an important role in the construction of aggregate productivity measures. The uneven development of Dutch manufacturing, with its strong bias towards lighter industries, further underlines the importance of so-called compositional effects.

In section four we broadened the scope by also including services in the analysis. Even though the international disparity in levels of labour productivity in services is not as large as in agriculture and manufacturing, our new estimates nevertheless point at less convergence in income and productivity levels on the eve of World War I than for example the Maddison estimates suggest. Applying the new benchmark estimates for 1910 to long term projections of value added and labour

back into the nineteenth century reveals an interesting new perspective on the dynamics of comparative long-term economic development. It supports the view of Broadberry and Irwin that the UK maintained an income lead until the closing decades of the nineteenth century, even though the UK income lead is much less impressive in the period 1850-1880 according to our calculations. The new time-series on comparative labour productivity lend more support to Ward and Devereux as they unequivocally show that the UK had lost its productivity leadership already midway the nineteenth century. Our new 1910 benchmark estimate for the Netherlands has enormous implications for the dynamics of long-run comparative economic development. The new series indicate that the Dutch lost their economic leadership already before 1820 and not somewhere in the 1850s, as is suggested by Maddison. This finding is in line with recent insights in Dutch historiography.

Rather than offering any definitive answers to the questions of long run economic growth and dynamics, our new 1910 benchmark estimate serves as a starting point for further investigations based on an industry-of-origin approach. A lot of work remains to be done on improving the quality of time-series of gross output, value added and employment for the nineteenth century, and in many cases the early twentieth century as well. In addition, expanding and improving estimates of service sector productivity is crucial to arrive at a more complete picture of convergence and divergence of income and productivity levels since the industrial revolution. Yet, the most important gains are probably made by expanding the geographical scope of this research.

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Appendix A: Primary and secondary sources used to calculate PPPs and estimate comparative labour productivity

UNITED STATES

Purchasing Power Parities (PPP)

Agriculture: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume V, Agriculture 1909 and 1910, General Report and Analysis* (Washington, 1913)

Mining: Department of the Interior, *United States Geological Survey, Mineral Resources of the United States 1910, Part 1 Metals* (Washington, 1911)

Construction: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington, 1913)

Utilities: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington, 1913) and *Census of Electrical Industries 1917*, central electric light and power stations

Manufacturing: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington, 1913)

Services:

Value Added (VA)

GDP at market prices: Balke and Gordon (1989), table 10, p. 84

Agriculture VA: *US Historical Statistics of the United States*, p. 4-193, serie DA 1066; Originally retrieved from Department of Agriculture, *Economic Research Service*, Table 1

Mining VA: Department of the Interior, *United States Geological Survey, Mineral Resources of the United States 1910, Part 1 Metals* (Washington, 1911)

Construction VA: Mitchell, B.R., *International Historical Statistics, The Americas, 1750-2000,* 5th edition, (London, 2003)

Utilities VA:

Manufacturing VA: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington, 1913)

Services VA: Obtained by deducting agriculture and industry from total economy.

Labour Force

Total employment: Kendrick (1961), table A-VII, p.308

Sectoral employment shares, except for manufacturing branches: Kendrick (1961), table A-VII, p.308

Manufacturing employment shares at branch level: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington, 1913)

Total Population: Maddison (2009)

UNITED KINGDOM

Purchasing Power Parities (PPP)

Agriculture: Board of Agriculture and Fisheries, *Agricultural Statistics (1907)*, Vol XLII, Part I, London: His Majesty's Stationary Office, 1907

Mining: Board of Trade, *Final Report on the First Census of Production of the United Kingdom (1907)*, London: His Majesty's Stationary Office, 1912

Construction: Burger (1994)

Utilities: Burger (1994)

Manufacturing: Board of Trade, *Final Report on the First Census of Production of the United Kingdom (1907)*, London: His Majesty's Stationary Office, 1912

Services: Burger and Smits (1996); Broadberry and Irwin (2006).

Note: All UVRs based on 1907 prices have been adjusted with the final output deflator from Feinstein (1972) table 61, T132.

Value Added (VA)

GDP at market prices: Feinstein (1972) *Statistical Tables of National Income, Expenditure and Output of the U.K. 1855-1965*, table 3, T10

Sectoral VA shares for 1911, except for manufacturing branches: Feinstein (1972) *National Income, Expenditure and Output of the U.K. 1855-1965*, table 10.2, p. 208

Labour Force

Total employment: Feinstein (1972) *Statistical Tables of National Income, Expenditure and Output of the U.K. 1855-1965*, table 60, T131

Employment shares of 1911: Feinstein (1972*), Statistical Tables of National Income, Expenditure and Output of the U.K. 1855-1965*, table 60, T131

Total Population: Maddison (2009)

THE NETHERLANDS

Purchasing Power Parities (PPP)

Agriculture: Departement van Landbouw, Nijverheid en handel, *Verslag over den Landbouw in Nederland 1910* ('s-Gravenhage, 1911)

Mining: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage, 1920)

Construction: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage, 1920)

Utilities: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage, 1920)

Manufacturing: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* (’s-Gravenhage, 1920)

Services: Burger and Smits (1996)

Note: All manufacturing UVRs based on 1913 prices have been adjusted with sector specific wholesale price indices from Smits, Horlings and van Zanden (2000), Table D.1B-D.3D, pp. 124-53

Value Added (VA)

GDP at market prices of 1909: Smits, Horlings and van Zanden (2000), Table I.2, p. 221

Sectoral VA shares of 1909: Smits, Horlings and van Zanden (2000), tables D.1-D.3, pp. 121-55

Labour Force

Total employment of 1909: Smits, Horlings and van Zanden (2000), table B.3, p. 114

Employment shares of 1909: Smits, Horlings and van Zanden (2000), table B.3, p. 114

Total Population: Maddison (2009)

FRANCE

Purchasing Power Parities (PPP)

Agriculture: Ministere du Commerce, de l'Industrie, des Postes et des Telegraphes, Evaluation de la Production, fournis par les chambres de commerce (1910) et les statistiques administratives (1912), Paris (1917); Ministère du Travail et de la Prévoyance Social, *Annuaire Statistique de la France 1908*, Paris 1909; Ministère de l’Economie et des Finances, *Annuaire Statistique de la France 1966, Résumé Rétrospectif*, Soixante-Douzieme Volume, (Paris 1967)

Mining: Ministere du Commerce, de l'Industrie, des Postes et des Telegraphes, Evaluation de la Production, fournis par les chambres de commerce (1910) et les statistiques administratives (1912), Paris (1917); Ministère du Travail et de la Prévoyance Social, *Annuaire Statistique de la France 1908*, Paris 1909; Ministère de l’Economie et des Finances, *Annuaire Statistique de la France 1966, Résumé Rétrospectif*, Soixante-Douzieme Volume, (Paris 1967)

Construction: Burger (1994)

Utilities: Ministere du Commerce, de l'Industrie, des Postes et des Telegraphes, Evaluation de la Production, fournis par les chambres de commerce (1910) et les statistiques administratives (1912), Paris (1917)

Manufacturing: Ministere du Commerce, de l'Industrie, des Postes et des Telegraphes, Evaluation de la Production, fournis par les chambres de commerce (1910) et les statistiques administratives (1912), Paris (1917); Ministère du Travail et de la Prévoyance Social, *Annuaire Statistique de la France 1908*, Paris 1909; Ministère de l’Economie et des Finances, *Annuaire Statistique de la France 1966, Résumé Rétrospectif*, Soixante-Douzieme Volume, (Paris 1967)

Services: Services: Burger and Smits (1996)

Note: all UVRs based on 1908 price data have been adjusted with the price index of Toutain (1987)

Value Added (VA)

GDP at market prices of 1910: Toutain (1987) Chapitre 2. Les donneés annuelles (1815-1938)

Agriculture VA: Mitchell (2007) table J2, p. 1037

Mining VA: Dormois (2006) table A7

Construction VA: Dormois (2006) table A7

Utilities VA: Assumed to be 1,7% of total value added based on unweighted averages of the UK and the Netherlands.

Manufacturing VA: Dormois (2006) table A7

Services VA: Obtained by deducting agriculture and industry from total economy.

Labour Force

Total employment: Mitchell (2007) table B1, p. 153

Agriculture: Mitchell (2007) table B1, p. 153

Mining: Dormois (2006) table A7

Construction: Dormois (2006) table A7

Utilities: Assumed to be 0,5% of total employed based on unweighted averages of the UK and the Netherlands.

Manufacturing: Dormois (2006) table A7

Services: Obtained by deducting agriculture and industry from total labour force.

Total Population: Maddison (2009)